Notes on the Geology of Wise, Lee and Scott Counties, Virginia. By John J. Stevenson, Professor of Geology in the University of the City of New York. (With three wood cuts.)

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During the winter of 1880, General J. D. Imboden discovered valuable coal beds near the Big Stone gap in Wise county, Virginia, at about sixty miles from the Tennessee line. The property soon passed into the hands of Northern capitalists, for whom I have investigated its economic value. The facts obtained may be of interest, as the only attainable information respecting Southwest Virginia is contained in the brief memoirs by Prof. J. P. Lesley* and in Prof. Safford's Geology of Tennessee. I am under very especial obligation to General Imboden, who, previous to my arrival, had studied the general geology with much care.

The area to be described in this paper includes those portions of Wise, Lee and Scott counties which are drained by the forks of Powell river and by the North Fork of Clinch river. Its north-western boundary is Black mountain, a ridge of the Cumberlands, which here forms the line between Virginia and Kentucky. At some distance from the Tennessee line, Stone mountain separates itself from that mountain and follows a N. 56° E. trend for about fifty miles to the Little Stone gap, where it unites with Powell mountain, which comes from the west of south-west. No examination was made beyond that gap, but, according to the map accompanying Prof. Lesley's memoir of 1872, the two mountains separate again and are distinct for several miles further toward the east. Wallen's ridge begins midway in the valley between Stone and Powell mountain at three or four miles south of west from Little Stone gap, and continues rudely parallel with Stone mountain to somewhat more than a mile beyond the Big Stone gap. There it is divided by a narrow valley into Wallen's ridge and Poor Valley ridge, which continue beyond the State line into Tennessee.

Two forks of Powell river, known as Pigeon and Roaring, rise on the southern slope of Black mountain and unite at the head of the Big Stone gap. The South Fork rises in the valley between Powell mountain and Wallen's ridge, flows through the eastern extremity of the latter and unites with the river at barely a mile below the Big Stone gap. The North Fork of Clinch river rises in the valley between Wallen's ridge and Powell mountain and breaks through the latter mountain at the North Fork gap, which is about twenty-five miles south-west from the Little Stone gap. Thence it flows eastwardly to Clinch river.

Two lines of section were followed; one beginning on the crest of Stone mountain, at say a mile west from the Little Stone gap and crossing the valley to the crest of Powell mountain; the other beginning at Black mountain and continuing southward through the Big Stone gap, across both Poor Valley and Wallen's ridges to the south-eastern side of Powell

* Proceedings of this Society, 1862 and 1872.

mountain. Unfortunately, there was no opportunity to make accurate measurements of horizontal distances and the scale of the cross-sections is probably somewhat distorted. In neither case was Powell mountain crossed along the line of section and the details respecting its southern side are taken from features observed in the North Fork gap.

The western section is shown in Fig. 1.

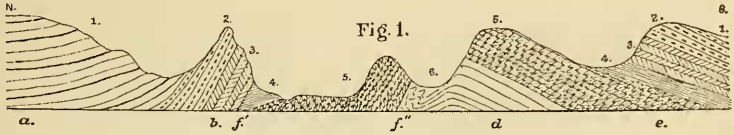

Fig. 1.

Fig. 1.—Cross-section from crest of Black Mountain to south-eastern side of Powell Mountain. *a*, Black Mountain; *b*, Stone Mountain; *c*, Poor Valley Ridge; *d*, Wallen's Ridge; *e*, Powell Mountain; *f'*, Stone Mountain fault; *f''*, fault of Poor Valley Ridge. 1, Coal Measures; 2, Conglomerate; 3, Lower Carboniferous; 4, Devonian; 5, Upper Silurian; 6, Lower Silurian.

Beginning at Black mountain, one finds himself amid the Coal Measures; going southward, he sees a slow but steady increase in dip until, as he approaches the Big Stone gap, it becomes nearly two degrees. But there the increase is very rapid, so that at the head of the gap the Seral conglomerate is dipping north-north-west at 80 degrees. The Lower Carboniferous limestone forms a bold cliff on both sides near the mouth of the gap and dips in the same direction at 70 degrees. Here a fault occurs, and one comes at once to *black shales* of unknown thickness, dipping in like direction at barely 20 degrees. Below these are the Lower Helderberg rocks, well exposed and of considerable thickness. On the south side of the Poor valley, and the northern slope of Poor Valley ridge, are the Clinton rocks with the fossiliferous ores, which continue to the head of Cedar gap, through which one comes to Turkey cove, separating Poor Valley ridge from Wallen's ridge. At the head of this gap, one crosses another fault and soon comes to the Trenton limestone, which is pressed into many short, close curves, but finally takes an almost due east dip on the northerly face of Wallen's ridge. The Medina sandstone is shown on the crest of that ridge, while the Clinton and Lower Helderderg rocks are well exposed in the valley between Wallen's ridge and Powell mountain. The black shales appear in the side of the latter ridge, with the Lower Carboniferous limestone higher up and the Conglomerate at the crest. On the opposite side of the mountain Hunter's valley is reached and there one finds the Coal Measures.

The other section, extending from the crest of Stone mountain to that of Powell mountain, is not more than seven miles distant from the other section, but it shows a great difference in the structure.

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Here, beginning at Stone mountain, one finds as before the Coal Measures, Conglomerate and Lower Carboniferous forming that mountain; in the valley, the black shales are shown at the base of each ridge, while the Lower Helderberg rocks occupy the center of the valley, where they describe an anticlinal, exceedingly sharp near the axis, but showing much gentler dips on each side as Stone and Powell mountains are approached.

Fig. 2.

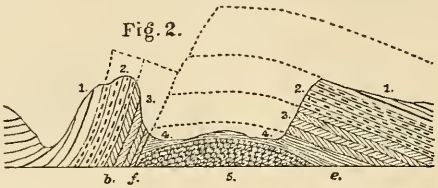

FIG. 2.—Cross-section from crest of Stone Mountain to that of Powell Mountain. The dotted lines show extent of material removed by erosion.

It is altogether probable from the best information attainable that a fault, rudely parallel to Stone mountain, exists in Kentucky at but a little way from the State line.

The general structure of the region between Black mountain and the Clinch river will be discussed in another part of this paper.

The Coal area between Black mountain and Stone mountain is extensive, but that within Hunter's valley is insignificant.

The Coal Area Drained by Pigeon and Roaring Forks of Powell River.

The Coal area, which begins immediately behind Stone mountain and extends thence to beyond the crest of Black mountain, is evidently the same with the Kentucky series, so well exposed in Harlan and Letcher counties of that State. The upper part of the Seral (Pottsville) Conglomerate forms the northern face of Stone mountain and the Coal Measures come in at the foot of the ridge, where the dip is very nearly vertical.

A series of barometrical observations shows that the series rises eastward from the mouth of Callahan creek, about a mile above the head of Big Stone gap. This rise of the whole region is rapid and is sufficient, if continuous, to carry most of the beds into the air within a few miles; so that only the lowest beds could be found at but a little way beyond the Little Stone gap.

For the most part, this region is still a wilderness, and exposures rarely occur except in the stream beds, which, owing to rapid fall, are usually clear. Several of the tributaries to Roaring fork were followed almost to their heads in the south-east side of Black mountain; and this general section was compiled from the measurements made on them.

1.	Not examined in detail	500′
2.	*Coal bed*	0′ 4″
3.	Sandstone	30′
4.	*Coal bed*	1′ 5″
5.	Sandstone and shale	115′
6.	*Coal bed*	0′ 6″
7.	Sandstone	70′
8.	*Coal bed*	2′
9.	Fireclay with stigmaria	2′
10.	Sandstone	12′
11.	*Coal bed*	1′
12.	Sandstone	70′
13.	Shale	20′
14.	*Coal bed*	0′ 4″
15.	Sandstone	26′
16.	Shale	4′
17.	*Coal bed*	0′ 10″
18.	Ill exposed, mostly sandstone	65′
19.	*Coal bed*	7′ 3″
20.	Sandstone	35′
21.	*Coal bed*	3′ 6″
22.	Sandstone	60′
23.	*Coal bed*	3′ 6″
24.	Ill exposed, mostly sandstone	120′
25.	*Coal bed*	Blossom.
26.	Sandstone	70′
27.	*Coal bed*	1′
28.	Shale and sandstone	22′
29.	*Coal bed*	extreme thickness 15′
30.	Sandstone	45′
31.	Shale	from 0′ to 5′
32.	*Coal bed*	extreme thickness 8′
33.	Shale	6′
34.	Sandstone	35′
35.	*Carbonaceous* shale	0′ 4″
36.	Sandstone	70′
37.	Ill exposed, mostly sandstone	65′
38.	Sandstone	30′
39.	*Coal bed*	2′
40.	Shale	10′
41.	Sandstone	40′
42.	*Coal bed*	2′
43.	Shale and sandstone	100′ ?
44.	*Coal bed* and shale	5′
45.	Interval to conglomerate	estimated at 80′
	Total	1751′

Exposures become poor near the top of Black mountain along all of the streams which were followed, and the upper part of the section was not made out. Sandstones and shales seem to be continuous for 200 feet above the highest *coal bed* seen in place ; but there is certainly one *coal bed* within the undetermined interval beyond, as fragments of *cannel* were found abundantly at fully 200 feet up in that space. No limestone occurs in beds, but some nodular limestone was discovered within six feet above No. 17; and fragments of an exceedingly impure limestone, with a cone-in-cone structure in its more argillaceous portions, were found above No. 6.

Calahan creek is the main tributary of Roaring fork ; its larger branches are known as Kelly's, Church House and Preacher runs. Looney creek is an important stream entering Roaring fork near its junction with Pigeon fork. On all of these, as well as on Pigeon fork, exposures were found, but the upper part of the section was obtained satisfactorily only on Preacher run.

The study was not sufficiently prolonged to admit of classifying the beds or of determining their relations to the groups recognized in Pennsylvania. There seems, however, to be a natural line of division about midway in the section : for, above the *coal bed*, No. 19, to within 250 feet of the top of the column, no thick *coal bed* occurs. It may be that the lower portion, for about 833 feet, is equivalent to the Lower Coal Measures of Pennsylvania as represented on the Great Kanawha river of West Virginia, and that the upper portion is equivalent to the Lower Barren Group of Pennsylvania. I have noticed in another place* the extraordinary thickening of the Lower Coal Measures southward ; how this group, rarely more than 350 feet thick in Pennsylvania increases southward from the line of the Baltimore and Ohio railroad in West Virginia, until in Randolph county it is 700 or 800 feet thick. The increase continues southward and on the Great Kanawha the same group is upwards of 1200 feet thick.

On the Kanawha, the top of this group is distinct ; for the "*flint ledge,*" occurring in close proximity to the Mahoning sandstone, is a well-marked horizon. But on the headwaters of Powell river the "*flint ledge*" seems to be wanting, and no traces of it could be found. The division here, therefore, is arbitrary and a final determination of the matter must be postponed until opportunity has been had for less hurried investigation. It is quite possible that the full thickness of the group is not given in the section, as the lower intervals were merely estimated.

If the top of the Kanawha series be at *coal bed*, No. 19, some representative of the Upper Productive Coal Series of Pennsylvania may be sought near the crest of Black mountain ; for while the Lower Productive Coal Series shows the remarkable increase southward, the Lower Barren Group shows no such increase. Its extremes are 500 and 700 feet, both of which may be found within the limits of a single township in different parts of Pennsylvania. No system of variation in this group has been discovered,

* Proceedings of this Society for 1875. Notes on Geology of West Virginia, No. II.

possibly because the group possesses comparatively little economic importance, so that it has received less study than has been given to the other coal groups of Pennsylvania. But the close investigation, which Mr. W. G. Platt has been making of this group for the Pennsylvania Geological Survey may remove the obscurity.

The *coal bed*, No. 19, as exposed on Preacher run, has the following structure :

1. *Cannel*	2′	
2. Shale	0′ 4″	
3. Slaty *coal*	0′ 4″	
4. Shale	0′ 5″	7′ 3″
5. *Coal*	0′ 5″	
6. Shale	0′ 4″	
7. *Coal*	3′ 5″	

The *cannel* is compact and much like that which is obtained in Armstrong county of Pennsylvania. It contains many fragments of sandstone, whose presence seems to indicate that the material of which the *coal* was made was pulpy, not like that which accumulated to form the ordinary beds. No distortion of the *coal* appears, such as was seen about the large fragment which I discovered* in the *Sewickley coal bed* in Fayette county, Pennsylvania. The fragments are small and angular, and doubtless they were attached to some tree, which had been uprooted during a freshet. The same bed was seen on Calahan creek, where it shows :

Coal	0′ 5″	
Shale	10′	
Coal	1′ 2″	19′
Shale	7′	
Coal	0′ 5″	

and is therefore worthless.

Coal bed, No. 21, is exposed on Preacher run and Calahan creek, and fragments of it were seen on Looney creek, though the bed itself was not found. On Preacher run it is finely shown at two miles from the mouth of the stream, where it is from 3′ 6″ to 3′ thick and yields a *splint coal* of remarkably fine quality. The roof is a hard, compact sandstone and the *coal* shows but insignificant partings. An analysis of this coal by Mr. A. S. McCreath, of the Penn. Geol. Surv., gave

Water at 225°	0.880
Volatile matter	37.580
Fixed carbon	58.059
Sulphur	0.406
Ash	3.075

* Second Geol. Surv. of Penn. Rep. on Fayette and Westmoreland counties. [KK.] p. 216.

This *coal* is well adapted for use in the furnace, as it has an extremely low percentage of sulphur and ash. The analysis just given may be compared with one of the *Sharon* or *Block coal*, which is used extensively in the iron works of eastern Ohio. This is also by Mr. McCreath, and is given in Report MM of the 2d Geol. Surv. of Penn., p. 99.

Water at 225°	3.790
Volatile matter	35.300
Fixed carbon	53.875
Sulphur	0.675
Ash	6.360

Coal bed, No. 28, is very similar to the last. It is 3′ 6″ thick on Preacher run, but is 4′ 6″ on Looney creek. It is persistent throughout the area examined and holds its thickness well.

Only the blossom of No. 25 was seen. No. 27 is persistent but always thin. Lying as it does between two plates of hard sandstone, it is often useful in indicating the place of the large bed below.

Coal bed, No. 29, is exceedingly variable, though altogether persistent. It has been opened on Pigeon fork at probably two-thirds of a mile above the mouth of the stream, where it shows:

Coal	6′ 10″	14′ 10″
Shale	0′ 10″	
Coal	2′ 5″	
Shale, averaging	0′ 3″	
Coal	4′ 6″	

A similar structure was seen on the first branch of Pigeon fork, and at both localities the upper division is so slaty as to be apparently of little value. The middle division is soft, has a prismatic structure and cokes well; the lower division is, for the most part, a splint coal of very fair quality, though it is somewhat inclined to be slaty near the base. On Looney creek, only the middle and lower divisions remain, the upper division having been removed by a horseback of clay. The character of the remaining divisions is the same as on Pigeon fork, but the *coal* is more liked and that from the middle division is carried to long distances for use by blacksmiths. Eastward from Looney creek, the bed is exceedingly variable; on Preacher run it is but two inches thick, on Kelly's run it is insignificant, and on Church House run it seems to be not more than one foot. But at an exposure near Roaring fork, at about two miles above the head of Big Stone gap, the bed is evidently very thick, though the exposure is too indefinite to admit of definite measurement. At all localities the lower parting shows many impressions of *Sigillaria* and *Syringodendron*.

As the middle division of this bed seemed to be a good coking *coal*, a sample was forwarded to Mr. McCreath for analysis. Its composition is:

Water at 225°.....	1.610
Volatile matter.....	38.850
Fixed carbon.....	57.879
Sulphur.....	0.771
Ash.....	0.890

which shows it to be a gas coal of superior quality. The coke, in point of ash, cannot be excelled.

Coal bed, No. 32, is the most important and least variable bed of the series and it is likely to prove of great economical importance, as it will afford *coke* for working the vast deposits of iron ore which exist along the line of the Atlantic, Mississippi and Ohio railroad and in Northwestern North Carolina. It was seen on all of the streams except Looney and Calahan creeks, the place of the bed being concealed on those streams where the water runs over it. A line of springs marks its outcrop on Pigeon fork and the *coal* is exposed on the first branch of that fork. An imperfect opening on Church House run shows :

Coal.....	3′ 10″	7′ 9″
Shale.....	0′ 5″	
Coal.....	3′ 6″	

The top part of the bed for eleven inches is very hard, a true *splint*, which is an advantage, as the roof is not always secure ; but the remainder of the upper bench is very soft and much of it has a prismatic structure. The lower bench is somewhat less soft, but is very tender. The *coal* taken out at this opening cokes well. An exposure near the mouth of Preacher run shows :

Coal.....	2′ 8″	6′ 11″
Parting.....	——	
Coal.....	1′	
Shale.....	0′ 3″	
Coal.....	3′	

At a mile further up the run, the bed has the same structure, but is only 6′ 9″ thick. The coke made at the latter opening is very hard, porous and silvery. On Kelly's run the bed is somewhat thicker and shows :

Coal.....	4′ 5″	8′ 5″
Shale.....	0′ 3″	
Coal.....	3′ 9″	

But the character of the exposure is not such as to indicate the quality of the *coal*. The same bed is shown on a little branch of Roaring fork, where it is not far from eight feet thick. *Sigillaria* and *Syringodendron* impressions are numerous in the shale parting.

To determine the quality of the *coal*, samples were taken from all the benches except the hard *splint coal* on top. These yielded the following on analysis by Mr. McCreath :

Water at 225°	1.380
Volatile matter	35.920
Fixed carbon	60.591
Sulphur	0.594
Ash	1.515

It is therefore a *coking coal* of marvelous excellence. The coke will contain less than three per cent. of ash and barely a half per cent. of sulphur. This coke is far superior to that from the Connellsville region, and better than that from the Oxmoor Works in the Cahawba basin of Alabama. It is decidedly better than the coke from the New River region of West Virginia.

No. 39 is a persistent though valueless bed. It has been mined near the mouth of Church House run, where it is two feet thick and yields an inferior *splint coal*, which is very rich in sulphur. Its blossom appears in the bluff above the road alongside of Roaring fork for nearly two miles above the head of Big Stone gap.

The interval, No. 37, could not be made out. The whole face of the coal-area fronting on Roaring and Pigeon forks is injured by extensive slides, which conceal this interval everywhere.

No. 42 was seen above the mouth of Calahan creek in the bed of Roaring fork, and in the bed of Pigeon fork at probably a mile above its mouth. The *coal* is said to be very good, a condition due no doubt to the removal of its sulphur by the water.

The remainder of the section was not measured. The lower members rise quickly toward Stone mountain and the rate of dip varies so greatly that thicknesses could not be determined during a mere reconnaissance.

The Seral (Pottsville) Conglomerate.

The Conglomerate forms the northern side of Stone mountain and its cliffs dip N. N. W. at between 70 and 80 degrees. The intervals between these cliffs must be occupied by shales or very soft sandstones as they afford no exposures. The group as shown in the Big Stone gap is not less than 1000 feet thick, but, owing to the dense forest, it was impossible either to gain a general section or to get the detailed structure of any portion. It was not determined, therefore, whether or not the Quinnemont series of *coal* beds is present here. This cannot be ascertained until the foliage has fallen.

The sandstones in the cliffs vary from fine-grained to coarse conglomerate, the latter containing quartz pebbles as large as a pigeon's egg. The highest bed is a moderately fine-grained rock and is well shown at the head of the gap, where it dips at 80 degrees. This is known as the "Bee-rock," as the laurel blossoms covering it are the resort of immense numbers of bees during the early summer. It shows many rude impressions of *Sigillaria* and extends along the north face of Stone mountain to beyond the Little Stone gap.

The Lower Carboniferous.

Like the Conglomerate, these rocks are found only in the mountains, and details respecting their thickness and composition cannot be ascertained until after the foliage has disappeared. They are shown along the south face of Stone mountain from Little Stone gap westward to the Tennessee line, and on the northerly face of Powell mountain from that gap to the North Fork gap, where the Carboniferous series ends. The Umbral Limestone follows the left hand side of the gap until within a short distance of Clinch river.

No detailed exposure of the interval between the Conglomerate and the Umbral Limestone was discovered, but it is not far from 500 feet thick, and appears to be filled chiefly with red shale, of which a few short exposures were seen.

The limestone appears as a cliff along the southern face of Stone mountain and is well shown on both sides of Big Stone gap, where it dips N. N. W. at 70 degrees, and, as nearly as can be estimated, is between 250 and 300 feet thick. The turnpike is cut through it at Little Stone gap. Thence, along Powell mountain, it is seen as a broad band to the North Fork gap, where its outcrop bends eastward and follows the left hand side of the gap almost to Clinch river. For the most part, this rock is compact and fine grained, but some of the beds are granular. Chert, in nodules as large as an ordinary orange, is plentiful in one layer. Fossils occur throughout the mass, but the specimens are not silicified and the species are not readily identifiable. *Productus cora* and *Zaphrentis spinosa* were obtained near the mouth of Big Stone gap. Many layers of this limestone are very pure and yield a lime of superior quality. The rock is cavernous and the large caves in Powell mountain afforded a supply of saltpetre to the Confederates during the late war.

Whether or not rocks of *Vespertine* age have been brought up along the face of Stone mountain was not ascertained; but the position of the limestone at a few miles west from the Big Stone gap renders probable that no representative of that group has been brought up. On the northerly face of Powell mountain, however, the succession is unbroken and the Vespertine rocks are undoubtedly present there, although they are concealed. A *coal* bed exists in the North Fork gap at a considerable distance below the limestone and therefore belongs to this group. *Coal* from it was used at a catalan forge in the gap.

The Devonian Rocks.

The immense Devonian series of New York and Pennsylvania is insignificant here and is represented only by *black shales*, which are exposed along the foot of both Stone and Powell mountains. These shales cross the valley near Little Stone gap, where their dip is abrupt near the central line of the valley, but becomes gentler toward each mountain. They are the equivalent of Prof. Safford's "*Black shales.*" Their thickness was not determined accurately, but it cannot exceed 500 feet. No fossils were found in them.

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The Upper Silurian Rocks.

The Lower Helderberg, the Clinton and the Medina were recognized.

The Lower Helderberg.—The rocks of this group are exposed in the Poor valley; on the eastern end of Wallen's ridge; in the valley between Wallen's ridge and Powell mountain; in the North Fork gap, and on the south-eastern slope of Powell mountain beyond that gap. The exposures are very fair and a complete section could be obtained without much difficulty.

The estimated thickness is not far from 250 feet. For 70 feet from the bottom the series consists of limestones in beds of from three to five feet, separated by shales in somewhat thicker layers. The lower limestones are silicious, but, toward the top, the beds are purer and one of them, black, fetid and four feet thick, contains abundance of *Leperditia.* Overlying this is a succession of coarse-grained calcareous sandstones, shales and silicious limestones, not well exposed along the line followed in the attempt to secure a section. The lower calcareous sandstone is shown in a line of low hills near Big Stone gap, and also on the turnpike within a mile of Cedar gap; the larger of the silicious limestones is shown near the pike opposite the gap, and also on the north side of Powell river at barely a mile below the gap. It is very light in color and has a cherty look. Immediately above it is a coarse reddish-gray sandstone, closely resembling the Oriskany sandstone of New York.

The lower sandstone is well shown on the pike, where it seems to be made up almost wholly of casts of *Orthis oblata, Rhynchonella ventricosa,* and undetermined *Meristella.*

The silicious limestone yielded *Crinoid stems,* abundant; *Aspidocrinus scutelliformis; Chætetes; Favosites; Atrypa reticularis; Strophomena rhomboidalis; Strophodonta; Spirifer cyclopterus; Meristella; Rhynchonella nucleolata; Orthis oblata;* and other forms which were not recognized.

The immediately overlying sandstone has a broad *Meristella; Spirifer perlamellosa; Favosites; Caninia helderbergiæ;* the last two in great abundance.

At some distance up the valley, say four miles above the Big Stone gap, on property belonging to Mr. Spencer, the upper silicious limestone becomes impregnated with brown hematite. Usually only the joints have been filled, but occasionally for considerable distances the rock has been replaced by limonite. The ore is too silicious to be of any value. The fossils are distinct. Along the valley between Wallen's ridge and Powell mountain, the Lower Helderberg rocks can be followed easily; the silicious limestone and the lower calcareous sandstone have been replaced to a greater or less extent by brown hematite. The outcrop of the lower ore follows the hillside above the road for miles, while the upper bed follows the creek-bottom almost to the head of Wildcat creek. Much of the ore at the upper horizon is exceedingly poor, but there are some pockets of decidedly good material. The fossils are the same with those seen at the same horizon in the Poor

valley. The lower horizon makes a fine showing along the hillside and the fragments that have fallen to the road are often of such excellent quality that a passing observer might be led to suppose that the deposit is of uniformly good quality. Unfortunately, the ore here, as at every other locality, is variable. Much of it is merely the sandstone permeated with limonite, sometimes half its bulk being ore. There are, however, numerous pockets, some of them very large, which contain ore of marked excellence, as appears from the following analysis by Mr. McCreath :

Metallic iron	52.550
Sulphur	0.037
Phosphorus	0.051
Insoluble residue	7.840

Thus containing only .097 of phosphorus in 100 parts of iron.

This hematite occurs on the south-east face of Powell mountain beyond the North Fork gap, but no examination was made there to determine its extent or quality.

The Clinton Group.—In the low hills alongside of the turnpike and opposite the Big Stone gap, the following succession of the rocks underlying the Lower Helderberg was made out.

1. Mostly concealed, with here and there an insignificant exposure of sandstone ; probably contains some pure limestone, as fragments were seen on the surface. Estimated at ..... 250′
2. Red to yellow fissile shales, with thin layers of fine grit. Dip almost vertical ..... 60′
3. Imperfectly exposed ; has occasional layers of reddish grit ..... 35′
4. Fine grained calcareous grit, passing downward into silicious limestone. The upper half contains little calcareous matter and is very hard ; but toward the base, the rock becomes comparatively good limestone. No fossils were seen. The dip at the top is 70 degrees, but decreases downward, becoming 56 degrees at the base ..... 60′
5. A concealed interval ..... 75′
6. Deep red flaggy sandstone, very fine-grained and exceedingly hard ; dip is 30 degrees toward N. N. W. This rock contains many *Fucoids*, but no other fossils were seen except a weathered cast of *Orthoceras* ..... 8′
7. Shales, red to yellow, brittle, with thin layers of hard shale containing *Fucoids*. The dip is indistinct .... 50′
8. Silicious limestone, not unlike that seen in the Lower Helderberg ..... 5′

Below this, the succession is very indistinct along the three lines on which a section was attempted. The cherty limestone contains many fossils, but they are not well preserved, and the species are indistinct.

Below the rocks of the section is a series of shales and sandstones, in which are found the fossil ores of this group. No estimate of the whole thickness was made.

The Clinton rocks are well shown on the south side of Poor valley, and from the northern face of Poor Valley ridge. They occur on the north side of Wallen's ridge above the mouth of South Fork of Powell river, and are well exposed along the southerly face of that ridge for several miles. They appear also on the south-easterly slope of Powell mountain beyond the North Fork gap. At all of these localities the fossil ores are found.

Three beds of ore were seen in the Poor Valley region. The highest belongs probably within the concealed interval No. 7 of the section. It shows itself in the bank of Powell river at about half a mile from the gap with a thickness of from 5 to 8 inches, and a dip of 56 degrees toward N. 25° W. It is included in greenish shales, which are rich in *Fucoids*.

The second bed crops out in the "bottom" at say half a mile further down the river. It is important, and has the following structure:

Hard ore	4′ 8″
Soft ore	2′ 6″

The upper layer has very fair ore in its lower 20 inches, which could be used in a furnace. It is harder than the tender fossiliferous ore below, and contains fewer fossils, but it is much less hard than the other part of this layer. The strike is N. 40° E., and the dip is 45 degrees. The bed was followed for a considerable distance, but no material variation in thickness was observed.

A third bed was seen near Cedar gap, but the exposure there is somewhat indefinite. The hard ore predominates, and is far from being good.

The last two beds occur on Wallen's ridge at but a little way above the mouth of South Fork of Powell river.

Two beds only were seen on the south face of Wallen's ridge along Wildcat creek, a tributary to the South fork. One of these is 25 inches thick, and dips at 10 degrees in an almost east direction. The other bed shows:

Soft ore	2′
Hard ore	2′ 2″

overlying one foot of ferruginous shale, which rests on a flaggy sandstone. The upper part of the soft ore is almost granular, and can be removed with a shovel, but it is inferior to the other part, and contains many small rounded quartz pebbles. The hard ore shows very few fossils. The dip is 11 degrees and almost due east.

The ordinary ore of this region is very good, as appears from the following analysis by Mr. McCreath, of a specimen from Wallen's ridge:

Metallic iron	52.600
Sulphur	0.018
Phosphorus	0.116
Insoluble residue	18.140

there being but .220 of phosphorus in 100 parts of iron.

The very soft or granular ore was analyzed. It has the same character as the last, except that, owing to the presence of the quartz pebbles, the insoluble residue is very great. The proportion of phosphorus is .228 in 100 parts of iron.

Three beds were seen in the area along the south-east slope of Powell mountain beyond the North Fork gap. The highest one is thin and contains only silicious ore. The second bed shows:

Ore	1′
Shale	1′
Limestone and Ore	0′ 5″
Shale	0′ 4″
Ore	0′ 5″
Shale	0′ 4″
Ore	1′

At 50 feet below this, the interval being filled with sandstone, another bed was seen showing:

Very soft ore	1′ 3″
Hard ore	1′ 6″

The ore in both of these beds is leaner than that seen in Poor valley and on Wallen's ridge, but it can be mined very cheaply. These Powell mountain ores show the fossils much more distinctly than do those in the other localities and the forms are larger. *Leptocœlia hemispherica, Streptorhynchus subplana* and the pygidium of a *Calymene* occur abundantly.

The Medina Sandstone.—This was seen only on the crest of Wallen's ridge near the head of the valley separating that ridge from Poor Valley ridge. It is a moderately coarse, light gray sandstone, evidently more than 300 feet thick, and so far as observed contains no fossils.

The Lower Silurian Rocks.

No rocks of this age appear in the Poor valley within at least 15 miles west from the Big Stone gap; nor are they exposed between Wallen's ridge and Powell mountain between North Fork and Little Stone gap; nor do they come to the surface along the south-east slope of Powell mountain beyond that gap. But they are well exposed on the northerly face of Wallen's ridge and in Wallen's valley, which separates that ridge from Powell mountain beyond the North Fork gap.

Limestone is the prevailing rock and there is little reason to believe that even the base of the limestone of II is reached at any exposure within the area examined. With the limestone, shale is interstratified, which is sometimes fissile but often compact and not laminated. One cannot fail to note

the deep red color of the débris covering the outcrop of the limestone, which so often resembles the decomposed outcrop of a limonite bed.

In Wallen's ridge the limestone has an almost east dip, but in the valley between that ridge and Poor Valley ridge it is pressed into very close abrupt folds, in which the dips sometimes exceed 60 degrees. In these folds, too, the dip is twisted, so that instead of being east and west, it becomes first N. W. and S. E., and then N. N. W. and S. S. E. The lowest member of the series is a mass of reddish to yellow shales, which are so distorted that their thickness could not be determined. These, however, are probably only a part of the limestone series.

Whether or not any shales intervene between the limestone and the Medina sandstone above, was not ascertained, as a concealed interval occupies the space between the two formations. These rocks do not come to the surface again toward the east until near Clinch river, where Stock creek has eroded a tunnel through a hill of the limestone. In the limestone of Wallen's ridge, *Strophomena alternata*, *Leptæna sericea*, *Orthis occidentalis* and other species characteristic of the Trenton limestone occur abundantly.

General Structure of the Region between Black Mountain and Clinch River.

The following diagram, Fig. 3, which is a continuation of Fig. 1, represents the structure of the region between the fault of Poor Valley ridge and Clinch river:

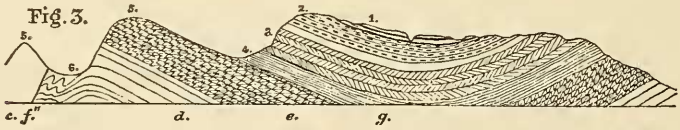

Fig. 3.—From Poor Valley Ridge to Clinch River. *g.*—Hunter Valley.

The Stone Mountain Fault is the "Clinch River uplift" of Prof. Lesley, which, according to his map of 1872, continues far toward the east and throughout its entire course is the southern and south-eastern border of the coal field.

The fault to which the mountain is due is sharp; the Umbral limestone on its southern face dips at 70 degrees; the Seral conglomerate, at more than 80 degrees; but the dip decreases with great rapidity, diminishing from 80 to 2 degrees within a very few rods and soon becoming less than 1 degree. Only the lowest rocks of the coal measures are involved in this abrupt dip and of those the projecting portions have been removed by Pigeon and Roaring forks of Powell river within the area visited.

Looking across the valley from Stone mountain to Powell mountain, one sees at once the relations of the Stone Mountain fault; for the Poor Valley Ridge fault is represented there only by a gentle anticlinal. The conditions are as shown in Fig. 2, where the dotted lines represent portions which have been removed by erosion; the whole section, as given in the diagram, is pre-

served at the head of the South Fork of Powell river, where the divide between that stream and the West Fork of Stone creek joins the two mountains. The figure exhibits the fact that here there is a cracked anticlinal, with the crack at some distance north from the line of the axis. The succession of the rocks on the south side of the axis is continuous from the Lower Helderberg to the Coal Measures, the latter being present in Hunter valley, on the southerly side of Powell mountain; but on the north side of the axis the succession is broken, and the Black Shales of the Devonian rest against the upturned beds of the Lower Carboniferous. It is evident that during the plication of the rocks the beds gave way, and that the lateral shove was so strong as to push those on one side of the fracture into an almost vertical position, while those on the other side were simply raised or perhaps pushed over on to the upturned edges of some lower rocks, which are not shown at the surface along the line of the fault. It is altogether probable that the rocks now occupying the valley along the southern foot of Stone mountain rest on beds of Vespertine age.

The vertical extent of this fault is less than one might suppose, and doubtless is little more than 6000 feet. The Devonian is represented here only by black shales, which are of inconsiderable thickness when compared with the great mass of Devonian rocks in New York and Pennsylvania. If erosion had not removed so much material along the Powell river and its tributaries, one might have found throughout only the condition indicated by the dotted lines in Fig. 2; and the vertical extent of the fault would have been regarded as altogether insignificant, for the Lower Carboniferous limestone is practically in contact on both sides of the fault in the vicinity of the Little Stone gap.

The Fault of Poor Valley Ridge.—A petty anticlinal exists between Powell and Stone mountain in the valley near the Little Stone gap. Its dips are more abrupt on the northern than they are on the southern side, while at the same time they are much more abrupt near the axial line than they are at a little distance from it. Only the Devonian and Lower Helderberg rocks are brought to the surface in the valley here.

At but a little toward the west a crack appears in this anticlinal and soon develops into the well-marked fault of Poor Valley ridge, which is approximately parallel to the Stone Mountain fault and lies at say three miles S. S. E. from it. Erosion has been actively at work along the southerly side of this fault and has divided Wallen's ridge into Poor valley ridge and Wallen's ridge, the separation first becoming distinct at Cedar gap, somewhat more than a mile below the mouth of the South Fork of Powell river.

As the two faults are approximately parallel, the dips are the same in direction on the northern side of both; but on the southerly side of the Poor Valley Ridge fault, the dips are almost due east, as is well shown at the head of Turkey cove. Entering this valley from the north by way of Cedar gap, one finds the structure represented in Fig. 1. The Clinton rocks on the north side of the fault strike N. 70° E. The Lower Silurian rocks, on the opposite side, which have been shoved into closely compressed

folds, have at first N. N. W. and S. S. E. dips ; but within a very short distance the direction changes to N. W. and S. E. ; and the veering toward the east continues until, on the side of Wallen's ridge, the great Trenton limestone dips at N. 80° E., very nearly the same as the strike of the Clinton rocks. Dips of 30 to 60 degrees are common enough on the northern side of the fault, but on the southerly side they seldom exceed 10 degrees.

The fault of Poor Valley ridge is evidently a cross fault. It continues into Tennessee and is crossed by Powell river.

The Region between Wallen's Ridge and Clinch River.—Wallen's ridge and Powell mountain are one in structure ; the valleys separating them are monoclinals ; and the beds shown on Powell mountain reached at one time to the crest of Wallen's ridge, or better, perhaps, to the fault which is the southerly line of the Poor Valley ridge. No detailed examinations were made beyond Powell mountain ; and the notes were obtained only while passing along the Estilville road from the head of North Fork gap to Clinch river. Some details respecting the conditions existing within a few miles further north-east were received from General Imboden, who had crossed Powell mountain into Hunter's valley.

If the reader will consult the map accompanying Prof. Lesley's memoir of 1872, he will see that Powell mountain curves somewhat sharply toward the south-east near the western edge of the map. This bend is due to erosion by a branch of the South Fork of Powell river, and marks no change in geological structure. A similar bend occurs at the North Fork, which is due to erosion by the North Fork of Clinch river.

There appears to be a general uplifting of the whole area south-westward ; for the dips grow gentler in that direction, and the synclinal between Wallen's ridge and Clinch river seems to grow shallower. The axis of elevation curves toward the south-west not far beyond the North Fork gap, and the dip on the slope of Powell mountain becomes south-east. The Carboniferous rocks do not extend beyond the North Fork gap ; and thence, as far as was examined, only the Upper Silurian rocks are shown on the slope of the ridge ; nothing newer than the Devonian black shales is present along the North Fork of Clinch river after it leaves the gap. Possibly the absence of the later rocks may be due in large measure to erosion. The Carboniferous rocks are well shown on the north-eastern side of the pass, until within two or three miles of the Clinch river. The axis of the synclinal was not observed. The Lower Silurian limestone was reached again on Stock creek, a tributary of Clinch, which within a mile of its mouth passes under a hill through a large tunnel excavated in the Trenton limestone.

This tunnel is properly regarded as a natural wonder. Its approaches are imposing, and the cliff of limestone, overhanging its mouth, is more than 450 feet high. A railway route was once surveyed through this tunnel, but the line was condemned as dangerous, since huge blocks of the limestone frequently fall from the overhanging cliff.

Drainage and Erosion.

Two forks of Powell river, Pigeon and Roaring, rise on the southern side of Black mountain and unite at the head of Big Stone gap, by which the resulting stream crosses the Stone Mountain fault. The South Fork of Powell river rises at the foot of Powell mountain near Little Stone gap; receives tributaries from the north side of that mountain as well as from the valley between it and Wallen's ridge; and, after crossing the fault of Poor valley ridge, by a shallow gap, joins the river at about a mile below Big Stone gap. Powell Mountain river flows between Stone mountain and Poor Valley ridge, for say fifteen miles, to opposite Pennington's gap, where it receives the North Fork. That stream rises on the slope of Black mountain and flows across the Stone Mountain fault by way of Pennington's gap. The main river, thus increased, flows southwardly for a little distance, and then crosses the fault of Poor Valley ridge.

The North Fork of Clinch river rises in the valley between Wallen's ridge and Powell mountain, and is separated by a low divide at its head from Wildcat creek, a tributary to the South Fork of Powell river. It flows along a monoclinal valley to the North Fork gap, which is sometimes known as Slemp's gap, where it turns toward the south-east. Within three or four miles, its course is again changed and the stream once more flows south-westwardly, following the foot of Powell mountain in a monoclinal valley.

Stock creek, another tributary to Clinch river, rises in Hunter valley, flows along the synclinal for several miles, then turns and flows up the dip to Clinch river. Clinch river itself rises far to the east of the region examined by me, and flows for a long distance near the line of the Stone Mountain fault, which it crosses and recrosses; but, at several miles east from the Little Stone gap, its course is changed, and the river for a while flows with the dip; but the course is again changed, and the direction becomes very nearly that of the strike.

It is sufficiently clear that the gaps through Stone mountain and Poor Valley ridge do not owe their origin to any convulsion of nature. The strike of the limestone and the conglomerate across Big Stone gap is perfectly true, and no evidence of a cross-fault or fracture is apparent there or in the coal-field behind the mountain. The absence of fracture is even more apparent in Pennington's gap through Stone mountain; for this gap is a tortuous passage-way with bold cliffs of the vertical conglomerate beds projecting from both sides. These cliffs afford ample evidence that erosion, not convulsion, produced the gap. The same condition is seen in the gap by which the South Fork of Powell crosses Wallen's ridge or the Poor Valley ridge fault. The North Fork gap in Powell mountain is as distinctly due to erosion as is the monoclinal valley along which the stream flows above the gap, or the tunnel by which Stock creek flows through a hill near Clinch river.

It may be stated positively that not one of the numerous gaps by which

streams cross the several faults and mountain ranges exhibits the faintest trace of any cross-fracture in the rocks.

At first glance, one might be inclined to suppose that the faults have influenced the direction of drainage. A deep valley has been excavated along the front of Stone mountain ; another, digged out of the contorted limestone and shale of the Lower Silurian, follows the fault of Poor Valley ridge ; the West Fork of Stone creek, a branch of Clinch river, has made for itself a broad valley near the Stone Mountain fault east from that of the South Fork of Powell river. These valleys arrest one's attention at once and they lie very near the lines of fault.

But valleys of equal importance are found where no fault exists to direct their course or extent. The monoclinal valley between Wallen's ridge and Powell mountain above the North Fork gap is as broad as the Turkey cove between Wallen's ridge and Poor Valley ridge ; Wallen's valley, between Wallen's ridge and Powell mountain beyond the North Fork gap, is a monoclinal, and is one of the finest valleys in Southwest Virginia ; the broad valley, followed by the North Fork of Clinch after it leaves the North Fork gap, is far removed from any line of faulting, and lies not far from the axis of the synclinal.

Erosion along the line of the Stone Mountain fault is interrupted, and the valley is far from being continuous ; a well-marked divide separates the South Fork from Powell river and a bold divide separates the South Fork of Powell from the West Fork of Stone creek. The condition is similar to that in the valley between Wallen's ridge and Powell mountain ; for a low divide intervenes between Wildcat creek and the North Fork of Clinch, while a high divide separates the latter stream from Wallen's creek, which flows along Wallen's valley.

The conditions in the immediate vicinity of the faulted lines appear to differ in no essential feature from those observed in less disturbed localities. It is evident :

First. That the course of the streams has not been determined by the lines of fault.

Secondly. That erosion along the faulted lines is essentially the same in character and extent with that in localities where no faults exist.

At the same time one may not ignore the fact that the faults have done much to hasten erosion along their lines as well as along the lines of streams belonging to the drainage system of Powell river, although one may be inclined to exaggerate the extent of this influence by forgetting that that drainage system is the important one in the region examined, while only a fragment of the Clinch river system falls within the area.

There must have been drainage before the faults existed. Evidently the rocks were more or less flexed previously ; for the dips in Wallen's ridge and Powell mountain are almost due east, whereas those on the northerly side of the faults are north-west to north-north-west. It seems not wholly improbable that the faults are of later date than the disturbance which pro-

duced the comparatively gentle synclinal between Wallen's ridge and the Clinch river.

The faulting process was not abrupt; though a geologist might think it so, for to him a thousand years is literally as one day, and the whole of the historical period is insignificant. But this process of elevation, fracture and lateral displacement, required a vast length of time. The corrasive force of the streams must have deepened the channel-ways as rapidly as the rocks were raised. It is quite possible that the present system of drainage is as old as Carboniferous times, and that the disturbance producing the faults led to comparatively little change in its direction.

Stated Meeting, September 17, 1880.

Present, 4 members.

President, Mr. Fraley, in the Chair.

Letters of acknowledgment were received from the Physical Society in Berlin, Jan. 2, 1880 (102, 103, XV, ii); Astronomical Society at Leipsig, Aug. 20 (104, 105); Association for National Science in Würtemburg, April 30 (102, 103, XV, i, ii); Agricultural and Historical Society at Lyons, March 10 (1 to 16, 18 to 20, 22, 24, 25, 27, 28, 32, 33, 35 to 62, 65 to 96, 98); Royal Academy, Amsterdam, Oct. 24, 1879 (102, 103); Massachusetts Historical Society, 30 Tremont Street, Boston, Aug. 12, 1880 (106, List); Public Library, New Bedford, Sep. 1 (106, List); Yale College, Aug. 26 (106, List); University of the City of New York, Sep. 1 (106, List); Astor Library, Sep. 13 (106, List); Regents of N. Y. University, Albany, Sep. 3 (106, List); N. Y. Historical Society, Aug. 23 (106, List); Penn. Historical Society, Sep. 7 (106, List); Maryland Historical Society, Sep. 6 (106, List); U. S. Coast Survey, Washington, D. C., Aug. 21 (106, List); Chicago Historical Society, Aug. 23 (106, List).

Letters of envoy were received from the Geological Survey of India dated Geological Survey Office, Calcutta, March 18, 1880, signed H. B. Medlicott, Supt.; L'Academie Royale des sciences, lettres et arts de Modene, dated July 31, 1880; Geologisch-botanische gesellschaft, Wien, I. Herren-